

NAMES _____
(Prior coordination with me is required if more than two of you work together on this project)
Section: _____
Physics 315
Problem Set 4
100 points
Due: *Beginning of class*, Lesson 33

To receive full credit you must show all work, communicate efficiently using proper grammar, and for every short answer (e.g. yes, no, maybe, it depends, I don't know) include an explanation why. On all answers requiring calculations, **SHOW YOUR WORK**.

AUTHORIZED RESOURCES: *any published or unpublished sources and any individuals.*

Document appropriately! _____

1. Explain the difference between PRF jittering and PRF switching.
2. Your radar is a chirp mode with a pulse width of 200ns, a frequency of 10GHz, and a sweep rate of 0.1 kHz/ns. If the radar has 10 frequency filters with identical passband widths with which to decode the returns, what is the range resolution of the radar?
3. You are in a close-in engagement and your radar has automatically transferred to a dogfight mode that uses FM ranging with an alternate, two-slope cycle sweep pattern. You know that the sweep rate is 0.05 kHz/ns and that the measured frequency difference on the upward sweep is 800 kHz and the measured frequency difference on the downward sweep is 200 kHz. Explain how you can determine whether the target has an opening or closing velocity. What is the target's range? Draw a diagram similar to Figure 6 on page 179 of *Stimson* to illustrate your answer.
4. Small closure rates result in small Doppler shifts, and are therefore harder to detect (resolve). Your radar operates at 10 GHz with a pulse width of 500 μ s (5×10^{-4} s). Given a 3 knot (1.5 m/s) closure rate with your target, determine the associated Doppler shift, f_d . Sketch the single-pulse frequency spectrum of this radar (ensure you have the correct BW_{nn} and center frequency), and indicate by a vertical line of a different color where the peak of the returned, Doppler-shifted signal would be. Could you resolve this shift using "one ping only"?

5. In order to resolve the shifted frequency from the reference frequency, we'll use the "Rayleigh Criteria" commonly associated with optics (see your Physics 215 book [Wolfsen, pp. 781-791]). The Rayleigh Criteria says you can just barely resolve two spectral lobes if the frequency of the peak of one lobe corresponds with the first null of the other lobe. Given your answer to question 4 and a PRF of 1000 Hz, how many pulses should your radar emit in order to make your line width (LW_{nn}) narrow enough to resolve the target's Doppler shift? Sketch the same single-pulse envelope as in problem 4, and then sketch the multiple-pulse spectrum based on the linewidth you determined in this problem. Make sure your lines are spaced appropriately. Add the spectrum of the returned, Doppler-shifted signal in a different color. You should see that the Doppler-shifted signal is now resolved.
6. Does a high or low PRF give a longer maximum unambiguous range? Use appropriate equations to support your answer
7. To allow for unambiguous range measurements of a target, describe whether you would want to make your maximum unambiguous range (greater than or less than) your (maximum or minimum) desired detection range. Why?
8. What are Doppler ambiguities? What causes them? Would your spectrum drawn for problem 5 have Doppler ambiguity?
9. In order to get rid of Doppler ambiguities, should you use a high or low PRF? If you can't get rid of Doppler ambiguities through this method, how can you resolve them? What is the minimum PRF you could use for the spectrum in problem 5 to eliminate any ambiguities? (Assume that having only one line under the main spectral lobe eliminates any ambiguity.)
10. Discuss the tradeoff between range and Doppler ambiguity based on PRF.
11. So "there you are", locked up by an unseen bandit who is probably miles away. Your RWR (radar warning receiver) is giving an audible signal that has the same frequency as the PRF of the bandit's transmission. You hear this tone change suddenly from a low-pitched buzz to a high-pitched squeal. What do you think the bandit might be doing with his radar and why?
12. The strange-looking diagram below is a Doppler spectrum. On this spectrum, clearly identify the main lobe clutter, the sidelobe clutter, and the altitude return. Assume you're in level flight with the radar pointing straight ahead and slightly down. How could you use this chart to determine your groundspeed? Identify on the spectrum where the following targets would be: a) head aspect bandit; b) co-air-speed tail aspect bandit; c) tail aspect bandit flying faster than you; and d) beam aspect bandit.

